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INTERIM REPORT - MANUFACTURING RESEARCH
BRAZING - HIGH TEMPERATURE AIRCRAFT
STRUCTURAL MATERIAL - DETERMINE METHOD FOR

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MANUFACTURING RESEARCH

BRAZING - HIGH TEMPERATURE AIRCRAFT

STRUCTURAL MATERIAL - DETERMINE METHODS FOR

SUBMITTED UNDER

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MANUFACTURING RESEARCH

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INTRODUCTION

With the higher operating temperatures that will be encountered in future aircraft, the requirements for strength and oxidation resistance at elevated temperatures will eliminate the use of the silver-base brazing alloys in sandwich panel construction.

Basic research on the brazability of alloys for high-temperature use was conducted under two separate Corporate Funded projects in 1958. As a result of this work, Rene' 41 was selected for consideration in applications to 1600 F and A-286 in applications to 1200 F.

This program was conducted to determine the effect of brazing cycles on the mechanical properties of the two alloys just mentioned and develop structurally sound brazed 6" x 6" honeycomb sandwich panels of each.

SUMMARY

The receipt of honeycomb core material of A-286 and Rene' 41 occasioned checking of previously obtained brazing results, using the foil gage materials. This work revealed that all the high temperature brazing alloys previously studied eroded and embrittled the honeycomb core during the brazing operation. Experiments to overcome these difficulties have resulted in the successful brazing of 6" x 6" panels in A-286. No brazing alloy has been found that is fully satisfactory for brazing honeycomb sandwich panels of Rene' 41. The results of high temperature oxidation and creep tests indicate that Rene' 41 will require some form of surface protection when used in thin sheet form at 1600 F.

The results of the tests conducted on honeycomb sandwich panels of A-286 brazed with an alloy of 65.2% Cu, 21.7% Mn, 8.7% Co, and 4.35% Ni indicate that this combination merits further investigation. This is a commercial composite referred to as Coast 1700 plus 10% Co and 5% Ni.

MANUFACTURING RESEARCH

BRAZING - HIGH TEMPERATURE AIRCRAFT

STRUCTURAL MATERIAL - DETERMINE METHODS FOR

OBJECT:

The objects of this test were: 1) To determine the brazing alloy most compatible for use with A-286 and Rene' 41 and the brazing characteristics, 2) to braze 6" x 6" honeycomb sandwich panels, and 3) to determine the effect of the brazing cycle on the mechanical properties of the alloys A-286 and Rene' 41.

DESCRIPTION OF SPECIMENS:

Two base metal alloys were selected on the basis of their high temperature mechanical properties for use in this investigation. They were A-286, proposed for use to 1200 F, and Rene' 41, proposed for use to 1600 F. Chemical analyses of the core material of these alloys as supplied by the fabricator are given in Table I. These are probably representative of the sheet material.

Samples of A-286 were received in sheets .010" and .051" thick and as type 415 honeycomb core, .500" thick. Rene' 41 was received in sheets .010", .020", .032", and .065" thick and as honeycomb core in the same size as the A-286 core. All the material was received in the mill annealed condition, referred to as condition "A".

Specimens for tensile, stress-rupture, and creep tests of the base metals were machined as shown in Figure 1. Brazed shear specimens were made as shown in Figure 2 and wet ground to the configuration shown in Figure 3.

The high temperature brazing alloys used in this investigation are listed in Table II. Due to the powdered form of nearly all the brazing alloys, only single skin sandwich specimens were made. Small sandwich specimens, approximately 3/4" x 3/4", were brazed using honeycomb core and one .010" thick skin for all the brazing, salt spray corrosion, and oxidation tests.

Edge and face compression specimens were made from brazed 6" x 6" honeycomb sandwich panels as shown in Figures 4 and 5. These panels were brazed with an alloy in foil form.*

*See Supplemental Sheet S-1

PROCEDURE:

Part A - Brazing & Testing of Small Panels:*

Small brazing specimens , 3/4" x 3/4", were prepared by wiring a piece of honeycomb core to a square of .010" thick skin material. A measured quantity of the powdered braze alloys was placed on the skin and retained in place with water or a dilute solution of borax during assembly. Thereafter, care was exercised to prevent loss of the braze alloy. This was not necessary with the three braze alloys obtained as foil, viz., Coast 1700 (75 Cu-25 Mn), Coast 1700 + 10% Ni, and Coast 1700 + 10% Co + 5% Ni.

Brazing of the small specimens was performed in a 2" diameter stainless steel tube inserted into a Marshall furnace. The end of the tube which was subjected to heat was closed. The other end was fitted with a flanged, gasketed closure clamped in place, permitting vacuum purging. The temperature in the retort was controlled by a thermocouple attached to one of the specimens. The cold tube was alternately purged with vacuum and argon gas at -100 F dry bulb, for a minimum of five cycles. Brazing was per formed in the argon atmosphere at atmospheric pressure.

Honeycomb sandwich panels, 6" x 6" size, were placed two high in a flat stainless steel retort. A 321 stainless steel plate .125" thick was placed under the bottom panel to assure flatness of the ´anels. A small amount of dry cobalt trifluoride, CoF_3, approximately 1/2 gram per retort, was placed under the plate, away from the sandwich specimens, to provide gaseous fluoride flux as an aid in brazing. The temperature within the retort was controlled by a thermocouple placed between the panels. The retorts were alternately purged with vacuum and argon gas, at -100 F dry bulb, while cold for a minimum of ten cycles. Brazing was performed in mercury, absolute pressure.

Oxidation tests were conducted by exposing small open-face honeycomb sandwich specimens in a electric furnace for a minimum of 100 hours. The same type of specimens were used to determine the corrosion resistance on exposure of 250 hours to salt spray.

Part B - Brazed Shear Tests:

Specimens for shear strength determinations were prepared with a gap of .0015" for brazing. The specimens were brazed and aged in a closed stainless steel retort. The specimens were subsequently wet ground to the configuration shown in Figure 3 for test.

Short-time shear tests were performed by loading the brazed area at an approximate rate of 6960 psi per minute.

*See Supplemental Sheet S-1.

Part C - Mechanical Property Determinations of Base Metals:

Tensile specimens were heat treated in a closed stainless steel retort in an electrically heated furnace. The specimens were separated by stainless steel wires .032" diameter, to promote uniform heating and cooling. The temperature was controlled by attaching a thermocouple to one specimen in each retort. The retorts were alternately purged with vacuum and argon gas, at -100 F dry bulb, for a minimum of five cycles. Solution treating and aging were performed in the argon atmosphere at atmospheric pressure. Tensile specimens were tested in a 5000 lb. Baldwin universal testing machine.* A Marshall furnace was used in the elevated temperature tests.

The specimens for stress rupture testing were heat treated and aged with the tensile specimens. A small number of the specimens were tested on Riehle creep machines, using a Marshall furnace.

RESULTS:

Considerable difficulty was encountered in machining specimens of Rene' 41, due to the work hardening characteristics of the alloy. Table III gives the hardness values of the Rene' 41 and A-286 alloys as received in the annealed condition and as heat treated. Table III also gives the hardness values obtained by exposing to various brazing temperatures and aging at 1400 F and the mechanical property values of the ribbon from which the honeycomb core was manufactured. The latter values were supplied by the honeycomb core manufacturer. Table IV gives the room temperature tensile properties of the Rene' 41 and A-286 alloys after heat treatment. Table V gives results of shear tests of brazed joints in these alloys.

Specimens of Rene' 41 for tensile testing exposed for 100 hours at 1400 F and at 1600 F were badly oxidized with both black and green oxides. Limited stress rupture testing of .035" thick Rene' 41 specimens at 1600 F gave the following results:

25.4 hours to failure at 15 ksi load
68.4, 42.9, and 34.6 hours to failure at 12.5 ksi load
161.1 hours to failure at 10 ksi load
50.9 hours to failure at 7.5 ksi load

Variations in the stress rupture life at this temperature are attributed to the excessive oxidation of the specimens during the test. A-286 tensile specimens exposed for 100 hours at 1200 F showed only superficial oxidation and are yet to be tested.

*Strain rate was approximately .003 in./in./min. thru yield.

Table II lists the commercial high temperature brazing alloys used in this investigation. Tables VI and VII list the approximate compositions of a series of powdered brazing alloys which were specially formulated in this work. These were used in efforts to determine the source of the eroding and embrittling action of the commercial brazing alloys on the thin honeycomb core materials. The results are included in Tables VI and VII.

The results of shear and brazed panel tests conducted on A-286 brazed with Coast 1700 + 10% Co + 5% Ni are given in Table VIII.

Figure 6 shows a typical condition encountered in the erosion of the honeycomb core materials at the nodes and intermittently along the fillets when brazed with the commercial alloys. Figures 7 through 14 are photomicrographs of brazed joints showing alloy structures and honeycomb core ends attacked by the high temperature brazing alloys.

Figure 15 shows the fillet and node flow of an A-286 panel brazed with Coast 1700 + 10% Co + 5% Ni. Figure 16 shows a typical fillet from the panel. Figure 17 shows a fillet after 250-hour salt spray exposure. Figure 18 shows a fillet after 120-hour exposure in air at 1200 F.

DISCUSSION

A-286 is an iron-base precipitation hardening alloy containing 2.1% Ti. The hardening phase is thought to be the compound Ni_3Ti. Rene' 41 is a nickel-base precipitation hardening alloy containing approximately 3% Ti and 1.5% Al. The hardening phase is thought to be $Ni_3(Ti,Al)$. The presence of aluminum and titanium in increasing amount has been found to increase the problems of brazing. Both alloys are difficult to braze without the use of a flux.

Tensile tests of the two base metals showed the materials responded favorably to heat treatment as compared with published data. The hardness values for Rene' 41 were somewhat low due to deliberately slow cooling from the solution temperature to simulate production cooling of structures from the brazing temperatures. However, the hardness value for A-286 was normal. Oxidation of Rene' 41 tensile specimens for 100 hours at 1400 and 1600 F showed that the alloy in sheet form oxidized badly at both temperatures. Limited stress rupture testing at 1600 F yielded the same result with a low stress rupture life. Some oxidation of the A-286 specimens exposed for 100 hours at 1200 F was apparent. No stress rupture tests were performed on A-286 at 1200 F.

Brazed shear strength values for commercial alloys joining Rene'41 and A-286 are given in Table V. The brazed joints were extremely hard and brittle.

Upon receipt of Rene' 41 and A-286 honeycomb core material, preliminary work consisted of checking previously obtained results on the .0015" thick materials. Single-face brazed sandwiches were made using Nicrobraz, Solabraz IX1, Coast 50, 52, 53, G.E. alloys J8100 and J8205, and a nickel-base alloy containing 24% palladium. Specimens were brazed with and without flux. It was found that poor brazes resulted when borax flux was not used. In both cases, however, the brazing alloys dissolved the thin core material selectively at the nodes where the larger amounts of brazing alloy concentrated, as is shown in Figure 6, and rendered the material quite brittle. Figures 7, 8, 9, and 10 show brazes made with some of the brazing alloys on A-286. Figure 11 shows Rene' 41 brazed with Solabraz IX1. This was the most satisfactory appearing brazement of the group.

Some brazing alloys with very low carbon content were received from Coast Metals, Inc. These were 52LC, 50 Sp.Co., 132E, Co Ti 3B, and Co Ti 2B. These also attacked the core excessively or gave poor brazes. Figures 6, 12, 13, and 14 show the results.

Experiments in mixing brazing alloys for determining the effects of various constituents were the following:

1. Varying the palladium content of Ni-Si-Cr alloy as indicated in Table VI.

2. Employing Mn, Cu, and Co in a Ni-Si-B alloy, as indicated in Table VII, to soften the braze alloy and lessen the attack on the core.

In this work, borax was used as a flux.

The experiments indicated that there was no advantage in using palladium in the high temperature brazing alloys of the Ni-Si-Cr type. It did not prevent the hardening effect of boron. In small amounts, it did not improve corrosion resistance, and in large amounts, it contributed to dissolution of the core. The experiments based on adding Mn, Cu, and Co to Ni-Si-B alloys were unsuccessful. The tests did indicate that a narrow melting range brazing alloy, or one low in B and Si will be necessary if the core erosion problem being encountered is to be overcome.

The brazed specimens listed in Table VII were oxidized in air for 100 hours. The exposure temperatures were 1200 F for A-286 and 1600 F for Rene' 41. The specimens of A-286 were in poor condition, and the Rene' 41 specimens were converted almost to oxide powders. Suspecting the dilute borax solution used as a flux, base metal specimens of A-286 and Rene' 41 honeycomb core and .010" thick sheet were dipped in dilute borax solution and allowed

to dry. The specimens were placed in furnaces alongside clean specimens of the same materials and oxidized for 100 hours at temperatures as above. The Rene 41 specimens with borax oxidized to powder while the clean specimens developed only surface oxides. The A-286 specimens with borax were more oxidized than the clean specimens.

Specimens were rebrazed without borax using Coast alloys 52LC, 53 [illegible] Ti 53, and 152E. The brazes were of poor quality, and the high hardness values of the brazement persisted.

In the fourth quarter, Coast 1700 alloys containing 10% Ni and 10% Co + 5% Ni were received with the manufacturer's assurances of corrosion resistance due to the nickel content. Preliminary brazing established that the corrosion resistance was good, although green compounds were formed on the surface of the base metals. The 10% Co 5% Ni alloy dissolved the core to a lesser extent during brazing than the alloy containing 10% Ni. The former was therefore selected for panel brazing tests.

Three 6" x 6" panels were brazed of A-286 with the Coast 1700 + 10% Co + 5% Ni brazing alloy and one of Rene 41 with the same brazing alloy. The three panels of A-286 appeared good, although it is believed that the quality of the braze could be improved by the use of more brazing alloy, possibly resulting in heavier fillets and nodes. The brazing alloy was in the form of foil .0015" thick. After pickling, the thickness was reduced to approximately .001". The Rene 41 panel was weak due to complete lack of node flow and intermittent formation of fillets.

Short time shear tests of A-286 brazed with Coast 1700 + 10% Co + 5% Ni gave average values of 49,020 psi at room temperature, 29,500 psi at 1000 F, and 19,600 psi at 1200 F. Three edge compression and two face compression specimens from the A-286 panels failed in the core when tested at room temperature. The values given in Table VIII, although considerably less than specified for 17-7PH brazed honeycomb sandwich panels, are about **as would be** expected for this alloy.

A-286 has a room temperature tensile yield strength of about 94 ksi as compared with 160 ksi for 17-7PH steel. The Coast 1700 + 10% Co + 5% Ni alloy did not harden the core or form hard brittle intermetallic compounds within the joint.

CONCLUSIONS

Brazed honeycomb sandwich panels, 6" x 6" size, of A-286 have been successfully made, using Coast 1700 + 10% cobalt + 5% nickel brazing alloy. The brazed panels have good resistance to salt spray corrosion and 1200 F oxidation. Microscopic examination revealed only slight core dissolution when a ten-minute brazing cycle was employed.

All the high temperature brazing alloys used in this investigation, with the exception of the copper-manganese base alloys, dissolved and embrittled core materials in A-286 and Rene' 41. This characteristic is undesirable in honeycomb sandwich construction.

No practical means has been found for applying powdered braze alloys to sheet materials to permit honeycomb sandwich construction. The carbon content of organic binders has adverse effects both on brazing and on the properties of the low carbon base metals. The use of borax as a combined binder and flux resulted in serious oxidation of Rene' 41 at 1600 F.

Although not entirely satisfactory, Solabraz IX, was the only high temperature brazing alloy found for brazing Rene' 41 honeycomb sandwich panels.

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2. W. W. Pratt, "Brazing Alloys, High Temperature Operating, Development of", MPE 58-2, February 17, 1959, Convair-FW.

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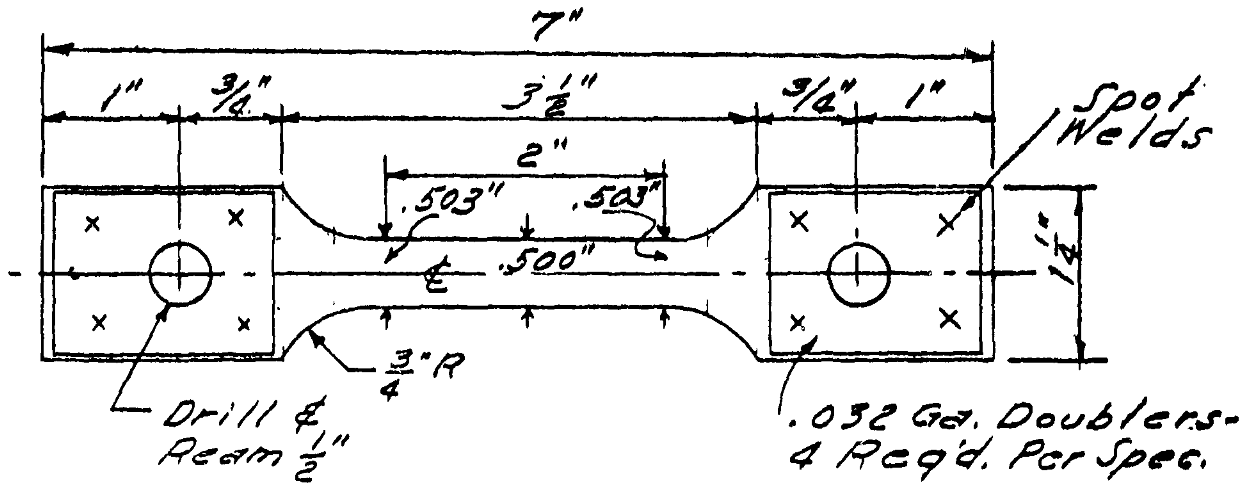


Figure 1
Tensile, Stress Rupture & Creep Specimens

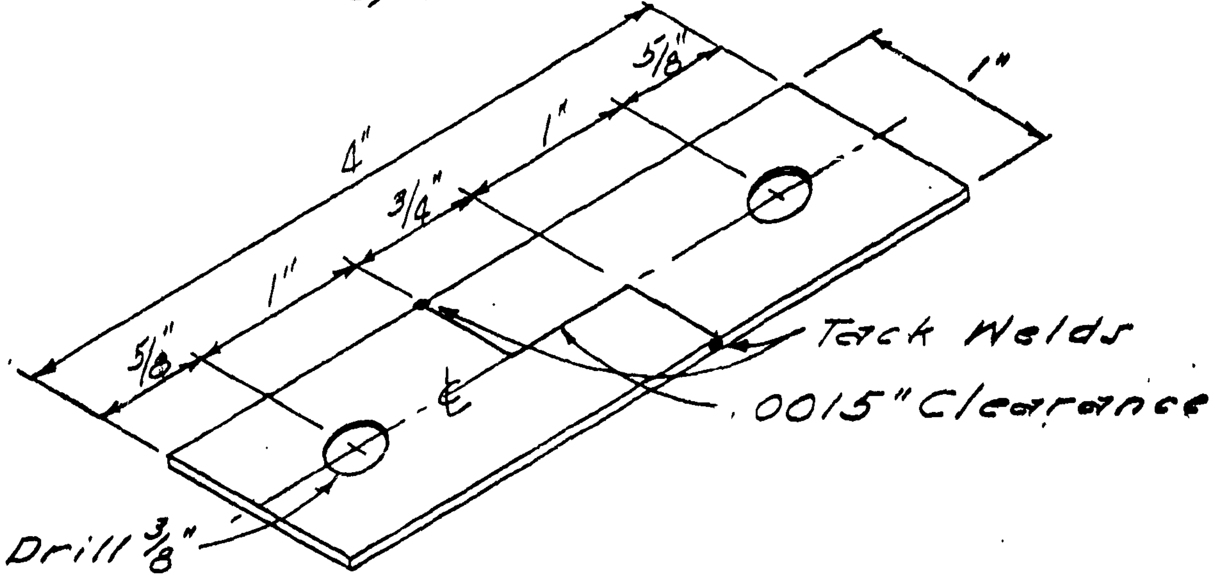


Figure 2

Shear Strength Specimen Ready For Brazing

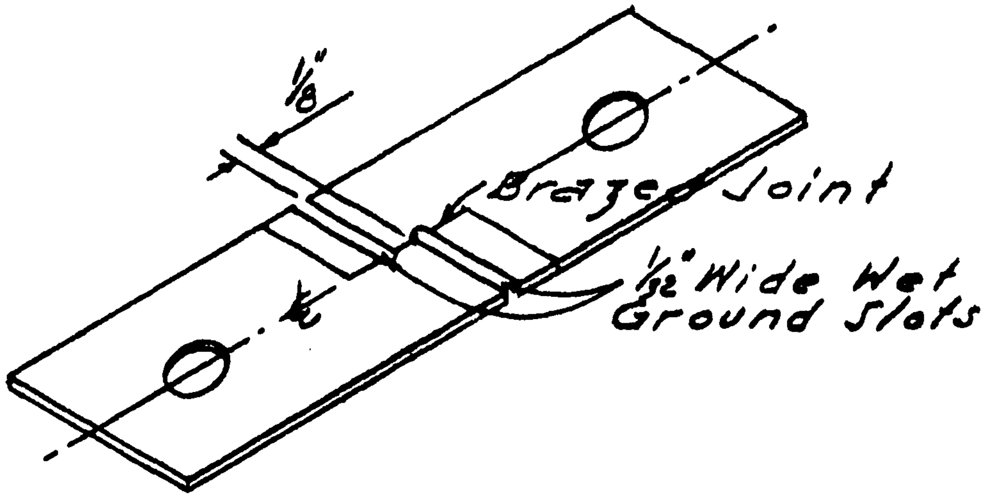


Figure 3

Brazed Shear Strength Specimen Ready For Test

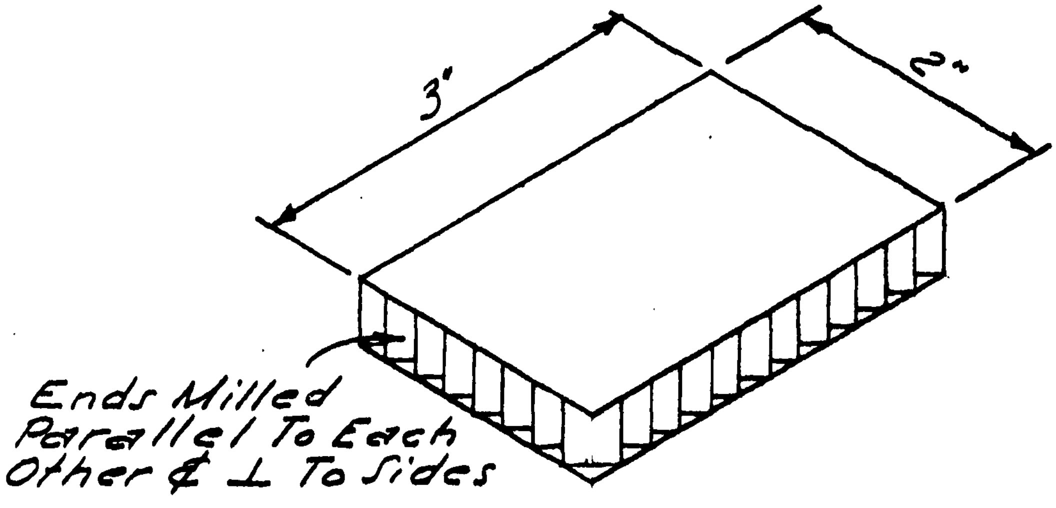


Figure 4

Edge Compression Specimen

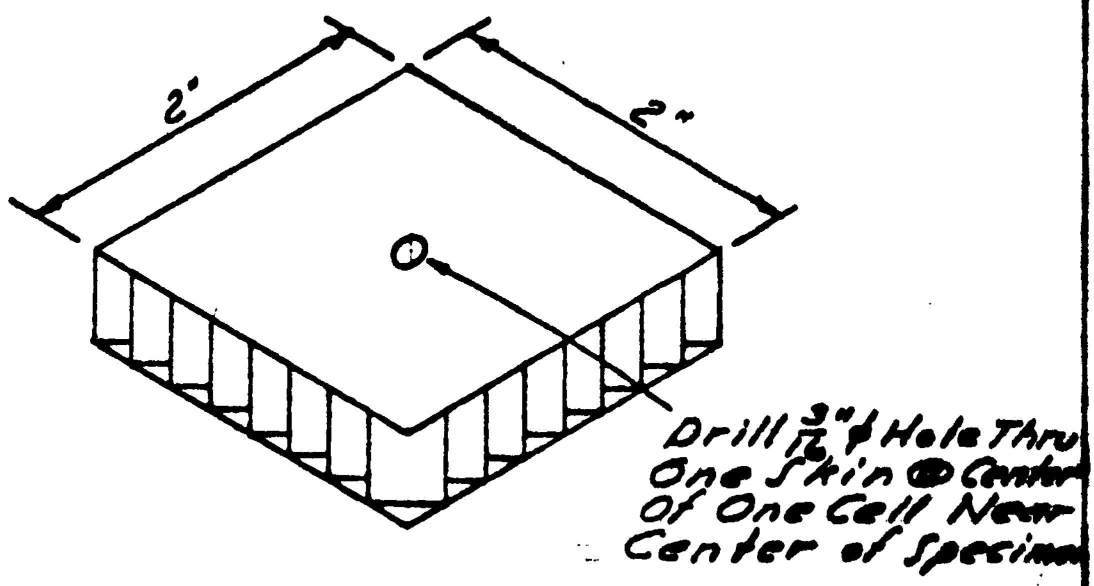
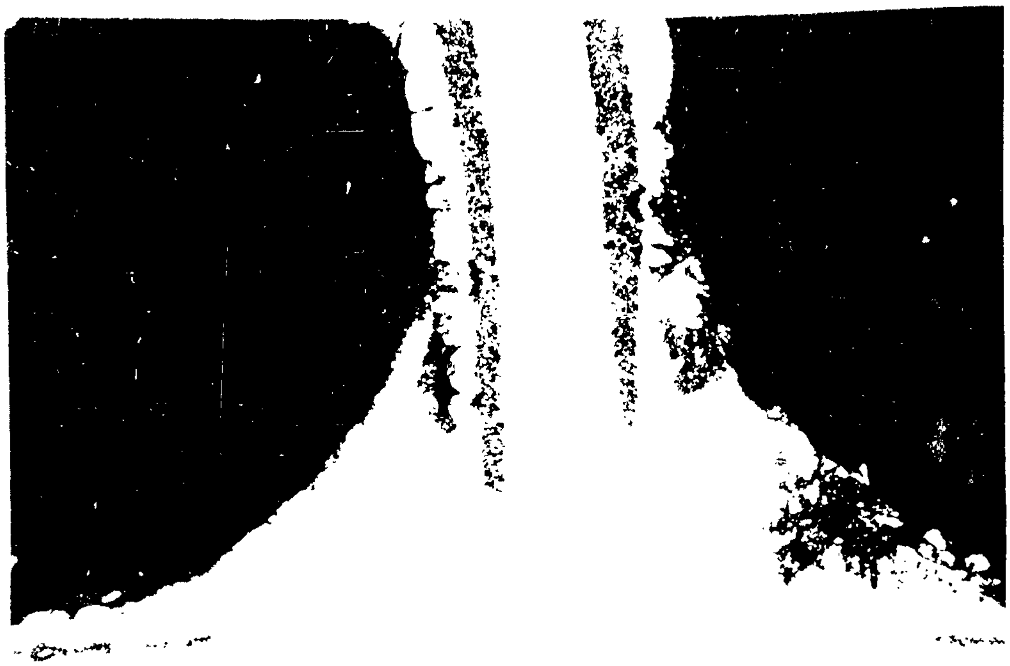
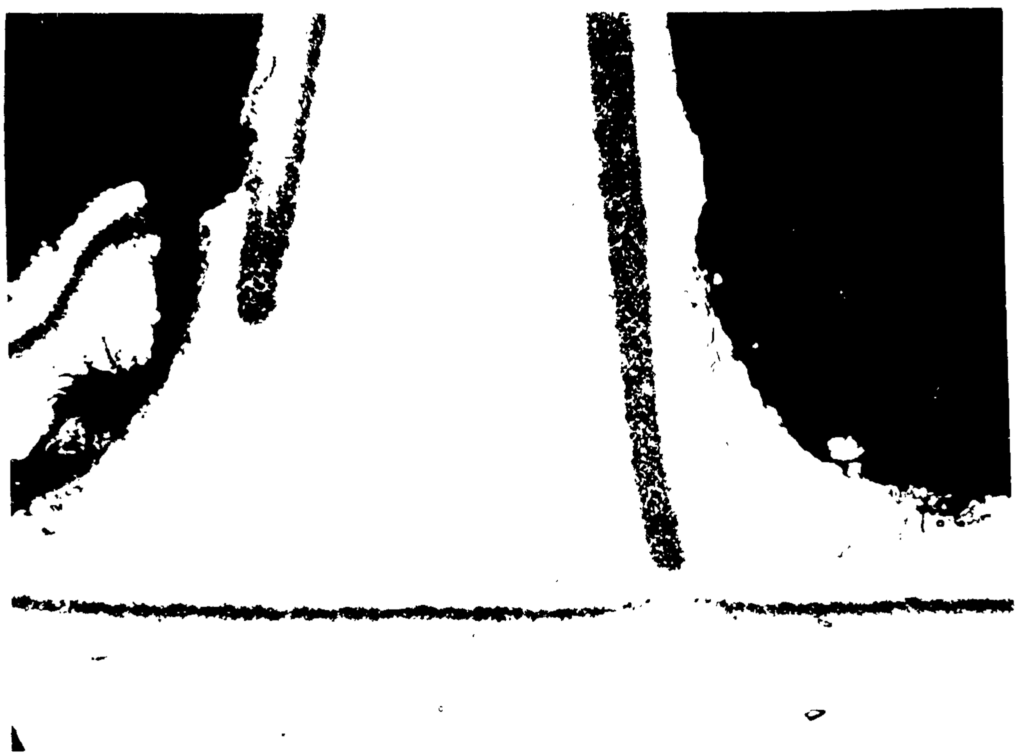
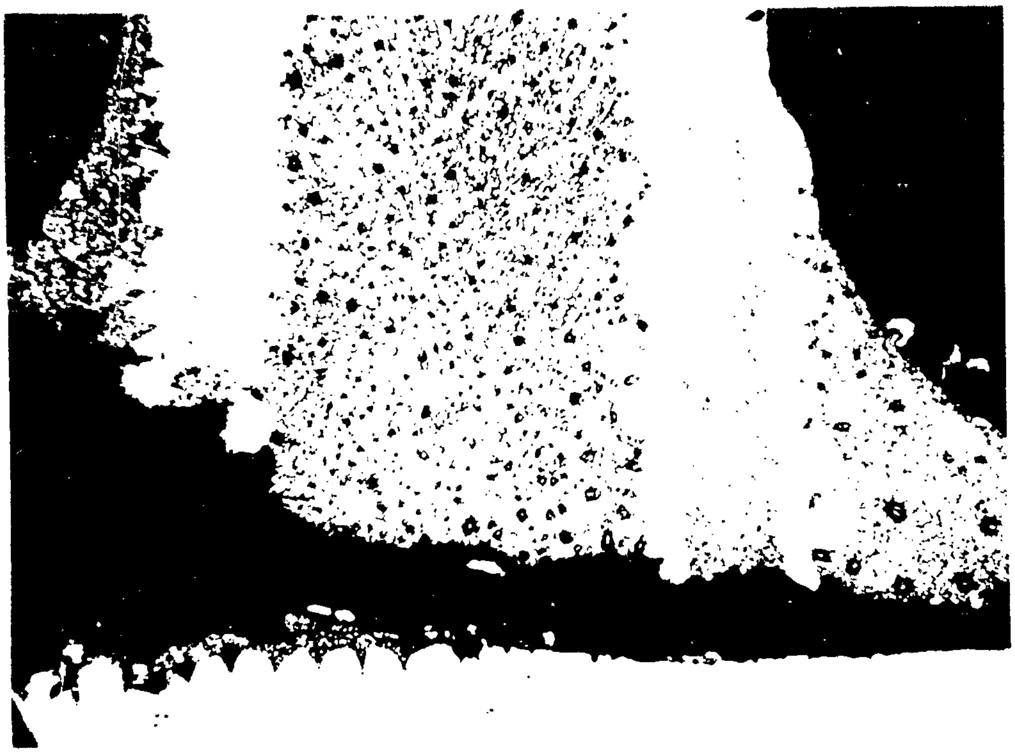
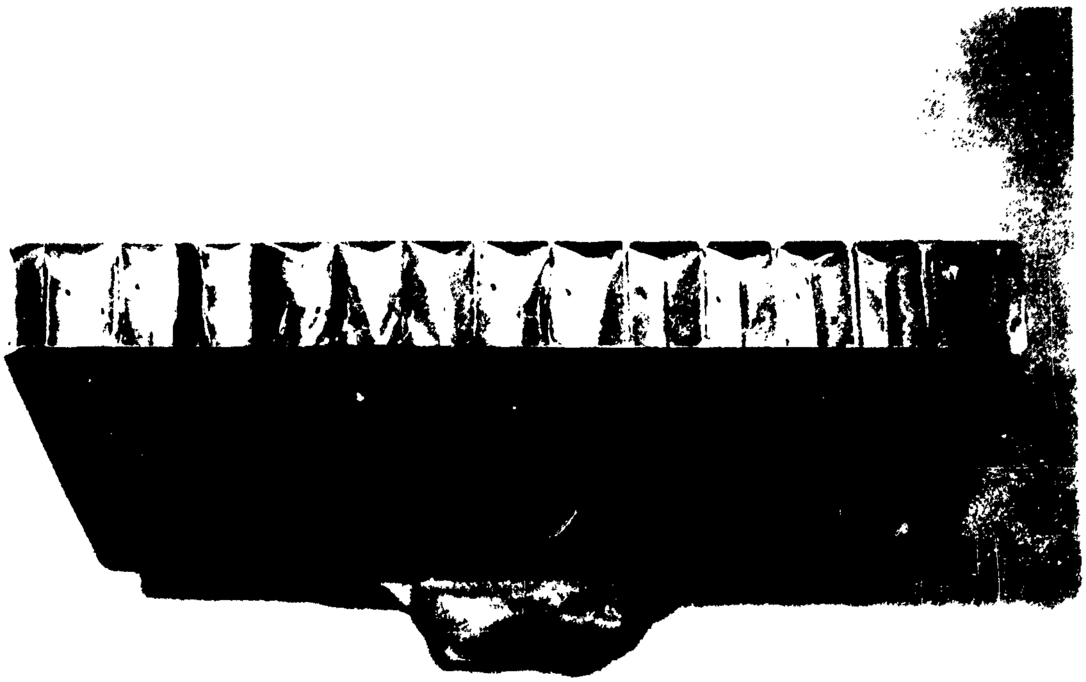


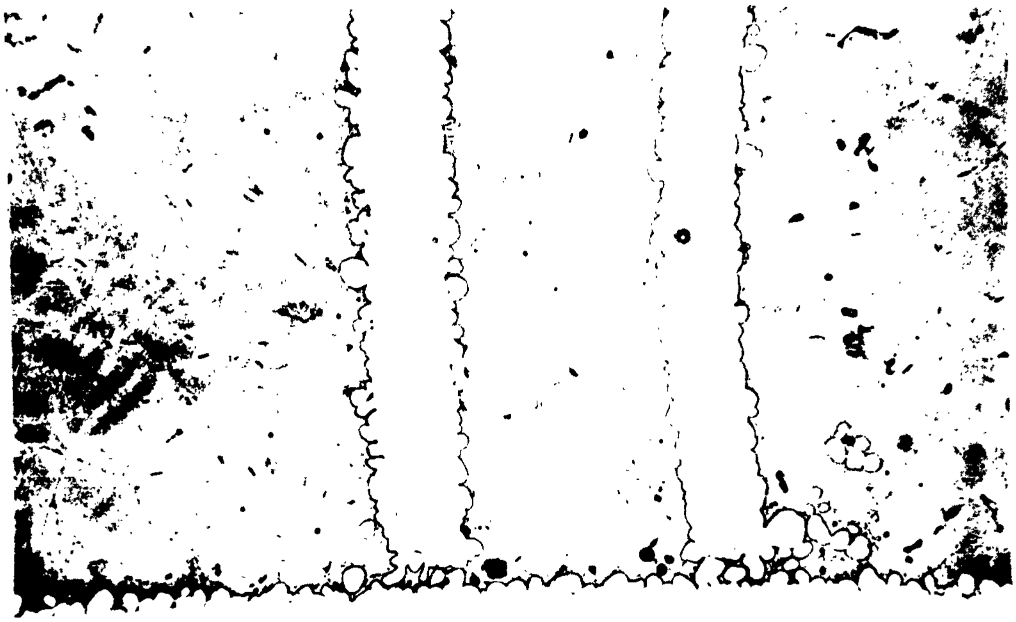
Figure 5
Face Compression Specimen











[illegible]

[illegible] after [illegible] exposure [illegible]

TABLE I

CHEMICAL ANALYSES* OF CORE MATERIAL USED IN THE INVESTIGATION

ELEMENT	RENE' 41	A-286
Nickel	54.9	25.04
Iron	.48	53.64
Chromium	19.11	15.04
Molybdenum	9.73	1.07
Cobalt	10.99	-----
Carbon	.11	.041
Manganese	.02	1.19
Aluminum	1.47	.18
Titanium	3.04	2.12
Silicon	.14	.76
Boron	.006	.0016
Vanadium	------	.30
Phosphorus	------	.025
Sulphur	------	.011

* As supplied by the fabricator

CONVAIR—FORT WORTH — Commercial High Temperature Brazing Alloys.

TABULATION SHEET

TABLE II

Alloy	Form	Braze Temp.	Ni.	Si.	B.	Cr.	Fe	Mn	Co.	Cu	Pd.	Cb.	
Coast 50	Pwdr.	1950	93.3	3.5	2.25								
Coast 52		1950	92.5	4.5	3.								
Coast 53		1950	82.1	4.5	2.9	7.	3.						
Nicrobraz		2100	74.	4.5	3.5	13.5	4.5						
Solabraz 1X1		1950	69-75	2-3			.5-2.5	15-25				.50	
J8100		2120	70.	10.	Yes.	19.	1.						
J8205		2120	70	10	Yes	19.							
Coast 52L.C.		1950	92.5	4.5	3.							Low	Carbon.
Coast 52 Spl.		1950	72.5	4.5	3.				20.			Low	Carbon.
Co. Ti 3B		1950	71.8	4.5	3.	.7 Ti.			20.			Low	Carbon
Co Ti 2B		2050	73.8	3.5	2.	.7 Ti.			20.			Low	Carbon
Coast 132E		1950	16.		Yes.			67.	16.				
Coast 1700	Foil	1750			Yes.			25		75			
Cst.1700+10%Ni		1900	9.1		Yes.			22.7		68.2			
Cst.1700+10%		1900											
Co+5%Ni			4.35		Yes.			21.7	8.7	65.2			
Palladium	Chips	1900	56.2	10.		9.8					24.		
Pd. Ni	Chips	2225	40								60.		

TABLE III

BASE METAL HARDNESS VALUES

BASE METAL	THICKNESS (IN.)	CONDITION	HARDNESS
Rene' 41	.012	Annealed	Rc 20 (From R_A)
	.012	H. T.	Rc 37.2 "
	.020	Annealed	Rc 22 (From R_D)
	.020	H. T.	Rc 35.6 "
	.035	Annealed	Rc 37.8
	.035	H. T.	Rc 41.7
A-286	.051	Annealed	R_B 78.5
	.051	H. T.	Rc 33.8

HONEYCOMB CORE MATERIAL PROPERTIES

MANUFACTURER'S DATA

BASE METAL	CONDITION	Fty, KSI	Ftu,KSI	% ELON.	HARDNESS
Rene' 41	Annealed	109.	156.4	14	15T93(R_B97+)
	Aged	183.4	202.1	2	15N82(Rc43)
A-286	Annealed	51.7	82.	13	15T85.5(R_B77)
	Aged	107.	126.8	6	15N74(Rc28)

- Cont'd -

Table III - Cont'd.

HARDNESS AFTER BRAZING FOR

TEN MINUTES & AGING AT 1400 F FOR SIXTEEN HOURS

BASE METAL	THICKNESS INCH	BRAZING TEMP. °F	HARDNESS Rc
Rene' 41	.066	1925	41.8
A-286	.051	1875	28.1
	.051	1950	26.4
	.051	2120	23.5

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TABULATION SHEET

Mechanical Properties Of René 41 & A-286 After Heat Treatment.

TABLE IV.

Spec. No.	Mtl.	Ga.	Wdth.	Area	Fty. Lbs	KSI	Ftu Lbs	KSI.	% Elon 2"
A-1	A-286	.051	.4945	.0252	2340	92.9	3610	143.2	21.
A-2	↓	↓	.496	.0253	2370	93.7	3615	142.3	20.
A-3			.4955	.0255	2415	94.7	3650	143.1	22.
	Avg.					93.8		142.9	21.
R-1	René 41	.032	.500	.0160	2435	152.2	3425	214.	18.
R-2	↓	.034	.494	.0168	2075	123.5	3575	212.7	17.5
R-3		.035	.494	.0173	2060	119.	3710	214.4	17.
	Avg.					131.6		213.7	17.5
R-4	René 41	.020	.501	.0100	1375	137.5	1870	187.	13.
R-5	↓	.019	.496	.0094	1310	139.3	1690	179.8	10.5
R-6		.019	.501	.0095	1230	129.4	1770	186.3	14.
	Avg.					135.4		184.4	12.5
R-7	René 41	.011	.496	.00545	770	141.2	1080	198.1	16.
R-8	↓	.011	.501	.00551	770	139.7	1090	197.8	17.
R-9		.011	.497	.00546	765	140.1	1040	190.4	22.5
	Avg.					140.3		195.4	18.5

Heat Treatment:

A-286 - Solution Treat 1800°F 1 Hr., Air Cool. Age 1400°F 16 Hrs.

René 41 - Solution Treat 1950°F 30 Min, Air Cool. Age 1400°F 16 Hrs.

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TABULATION SHEET - Shear Strength Values - Brazed A-286 & René 41

TABLE V

Spec. No.	Base Metal	Braze Alloy	Braze Temp.	Ga.	Wdth.	Area Braze	Test Temp.	KSI. To Fail.	
1	René 41	J8100	2120	.0675	.1265	.00854	Rm.	70.26	
6	↓	↓	↓	.066	.1242	.0082	Rm.	67.93	
2	↓	↓	↓	.068	.1372	.00865	1600	21.73	
4	↓	↓	↓	.067	.1541	.01032	1600	22.29	
7	↓	J8205	2120	.067	.1324	.00887	Rm.	53.33	
10	↓	↓	↓	.067	.1207	.00809	Rm.	57.17	
8	↓	↓	↓	.068	.1320	.00898	1600	12.25	
9	↓	↓	↓	.069	.1336	.00922	1600	11.93	
5	A286	Coast 50	1950	.0495	.1489	.00737	Rm.	57.7	Spec. Distorted.
6	↓	↓	↓	.045	.1124	.00506	↓	63.64	↓
7	↓	↓	↓	.0485	.093	.00451	↓	64.3	
18	↓	↓	↓	.0485	.1458	.00713	1000	60.45	
24	↓	↓	↓	.048	.1285	.00617	↓	60.62	
1	↓	↓	↓	.0485	.1077	.00522	1200	45.98	
15	↓	↓	↓	.0485	.1548	.00751	↓	52.73	
37	↓	Coast 53	1875	.0475	.097	.00461	Rm	59.22	
42	↓	↓	↓	.0475	.104	.00494	↓	42.31	
60	↓	Nicrobr.	2120	.047	.1462	.00687	Rm.	46.87	
61	↓	↓	↓	.045	.1159	.00523	↓	48.57	
62	↓	1X1	1950	.048	.1077	.00517	Rm	40.43	
63	↓	↓	↓	.048	.136	.00653	↓	48.55	
71	↓	↓	↓	.0475	.1466	.00696	↓	41.67	
75	↓	↓	↓	.047	.1049	.00493	↓	36.11	

CONVAIR—FORT WORTH
TABULATION SHEET

Brazing Results - Brazing Alloys Compounded To Vary Pd. & B. Contents.

TABLE VI

Alloy No.	Pd.	B.	Ni.	Si.	Cr.	Co.	Mn.	Cu.	Braze Temp.	Braze Time	Results.
1 B	12.	1.6	74	7.3	5.				1950	10 Min.	Atc Corr.
2 B	16.	1.	68	8.2	6.7						
3 B	18	.8	65	8.6	7.5						
4 B	20	.55	62.1	9.	8.3						
5 B L.C.	18	.75	65.3	8.6	7.3						
6 B L.C.	18	.75	60.3	8.6	7.3	5.					
5B+5% Germanium									1900		
6B+5% Germanium.											
1 C	9	1.4	59.7	5.4	3.7	4.	16.8		1950		
2C-.18Ti	9	.55	43.5	4.6	3.7	11.	25.				Crevice Corrosion.
3C-.11Ti	4	.4	21.7	2.25	1.6	3.3	16.6	50			Poor Braze - Weak After Corr.
4C-	8	.06	18.6	3.3	3.4		16.6	50			Crevice Corrosion
5C-.12Ti	6	.4	30.3	3.	2.5	7.3	25.	25			Localized Corrosion

CONVAIR—FORT WORTH
TABULATION SHEET

Brazing Results - Ni-Si-B Brazing Alloys Compounded To Vary Cu-Mn-Co Contents. TABLE VI

Spec. No.	Braze Temp.	Braze Time	Flux	Ni	Cu	Mn	Co	Si	B	Ti	Results Macro	Results Micro
1K	1950	3 Min	Borax	36	37.5	12.5	10.	2.	1.55	.35	Lumps*	
2K				47.9	25.	8.3	13.3	3.	2.	.46		
3K				47.	30.	10.	8.	2.7	1.8	.28		
4K				55.	25.	8.	6.6	3.	2.	.23	Fair - Ate Core	
5K				41.	37.5	12.5	5.	2.2	1.55	.17	Lumps - Ate Core	
6K				41.	30.	10.	14.	2.7	1.8	.42	Ate Core	
7K				61.5	25.	8.3		3.	2.			
8K				52.	30	10	4	2.	1.8	.14		
9K				69.	19	6.5		3.4	2.2		Good	Core Eaten
10K				55.5	30	10.		2.7	1.8		Lumps *	
11K				74.5	15	5.		3.6	2.45		Good	Core Eaten
12K				57.4	15	5	16	3.6	2.4	.56		
13K				63.5	19	6.5	5	3.4	2.3	.2	Ate Core	
14K				58.	19	6.5	10.	3.4	2.3	.35	Lumps *	
15K				46.	37.5	12.5		2.3	1.6			
52LC	1950	3 Min	None								Massive, Poor Wetting	
525pC												
132E												
6Ti3B											Poor Wetting	
11K												
9K												
13K												
7K												

* Lumps - Alloy Incompletely Melted

CONVAIR—FORT WORTH
TABULATION SHEET

Shear Strength Values - A-286 Brazed With Coast 1700 + 10% Co. + 5% Ni.

TABLE VIII

Spec. No.	Braze Temp.	Braze Time	Flux	Ga.	Wdth	Area	Test Temp.	Lbs. To Fail	P.S.I.	Remarks
86	1950	10 Min.	None	.049	.1320	.00647	Room	228	35250	Incomplete Braze.
108	↓	↓	↓	.049	.1415	.00693	↓	330	47592	
90	↓	↓	↓	.047	.1348	.00634	↓	307	48453	
105	↓	↓	↓	.0495	.1285	.00636	1000°	193	30341	
87	↓	↓	↓	.0485	.1372	.00665	↓	191	28705	
85	↓	↓	↓	.0505	.1419	.00717	↓	161	22467	Small Imperfection.
98	↓	↓	↓	.047	.1305	.00613	1200°	129	21030	
107	↓	↓	↓	.0485	.1415	.00686	↓	114	16611	Incomplete Braze
81	↓	↓	↓	.049	.1383	.00678	↓	123	18150	

Edge Compr. Values - A286 H.C. Sand. Panel - Room Temp.

Spec. No.	Skin Ga.	Cell	Core Ga.	Thk.	Wdth.	Lgth.	Area	Lbs.	P.S.I.	Type of Failure
1	.009	1/4"	.0015	.500	2"	3"	.036	3125	86805	Core Failure
2	↓	↓	↓	↓	↓	↓	↓	3125	86805	↓
3	↓	↓	↓	↓	↓	↓	↓	3260	90555	↓

Face Compr. Values - A286 H.C. Sand. Panel.

Spec. No.	Skin Ga.	Cell	Core Ga.	Thk.	Spec. Area	Temp. Test	Lbs.	P.S.I.	Type of Failure.
1	.009	1/4"	.0015	.500	4 Sq. In.	Rm	1780	445	Core Failure.
2	↓	↓	↓	↓	↓	↓	1330	332.5	↓

SUPPLEMENTAL INFORMATION

Testing of small sandwich panel test specimens was accomplished in a 60,000 pound Baldwin universal testing machine. The procedure for each type specimen is listed below:

1. Edge Compression Test

   a. The test machine loading head and platen are checked for parallelism and necessary adjustments made by shimming to insure parallelism.
   b. Test specimens are placed in the machine with the 3.00" edges normal to the bearing surfaces.
   c. Testing is accomplished by applying a continuous load to the 2.00" edge at a rate of 8,000 pounds per minute until failure.

2. Flat Compression Test

   a. The test machine is again checked and adjusted for parallelism as specified above.
   b. Test specimens are placed in the test machine in a flat position.
   c. Testing is accomplished by applying a continuous compressive load to the face of the specimen at a rate of 8,000 pounds per minute until failure.